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ABSTRACT

Reported is an investigation done to obtain descriptive answers to such questions as: What variables influence high school students' willingness to become personally involved with scientific activities? What variables influence these students' perception of the scientist? The study is described and includes an extensive review of the literature related to the topic. Potential predictor variables included those related to curriculum and instruction and those related to personal characteristics of the student. Instrumentation included a machine scorable instrument of Likert scales, two dimensions of academic self-concept, and over 40 other variables. Science educators in various parts of the country selected schools in their areas to maximize heterogeneity of cultural, socioeconomic and educational variables. Usable data were collected from 373 students. Results were analyzed by stepwise-deletion multiple regression. The alpha level accepted was set at 0.05. Approximately 31.8 percent of the variance of the attitudinal scores could be predicted from knowledge of: students' sex, their enrollment intentions with regard to advanced chemistry, whether or not they liked the physics teacher as a teacher, various test scores, and availability of the Science Course Improvement Project curricula. (Author/EB)

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POSSIBLE INFLUENCES ON STUDENT ATTITUDES TOWARD INVOLVEMENT WITH SCIENCE: Curricular, Demographic and Personal Factors

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Possible Influences on Student Attitudes Toward Involvement with Science: Curricular, Demographic, and personal factors.*

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The purpose of this investigation was to obtain descriptive answers to the following questions: (1) What variables influence high school students' stated (objectively identified) willingness to become personally involved with scientific activities? (2) What variables influence high school students' stated (objectively identified) perception of the scientist?

To answer the questions, an exploratory study was conducted to identify predictors (possible influences) of high school students' Attitudes toward Involvement with Science (AIS) and Perceptions of the Scientist (PS) which can be controlled or manipulated by the schools. Over 40 other hypothesized predictors were treated as co-variates. The availability of high school science curricula, particularly physics courses, developed since 1956 was of special interest.

Impetus

A person's attitudes, particularly his Attitude toward Involvement with Science (AIS) and his Perception of the Scientist (PS) are assumed to influence course selection, career selection, choice of leisure time activities and personal, political and financial decisions regarding support of scientific endeavors. The promotion of positive attitudes toward science is a universally accepted goal of science education. There is evidence this goal is not being achieved!

(1) A number of studies, such as Mead and Metraux (1957), Heath, et. al. (1957), Beardslee and O'Dowd (1961), and Snow and Cohen (1968) have revealed that high school students and others, while favoring science as long as it is

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*A paper presented at the 1975 Annual Meeting of the National Association for Research in Science Teaching.

distant and impersonal, are loathe to become personally involved with it and subscribe to negative stereotypes of "the scientist". Triandis (1971) describes such an attitude as reverence.

(2) As reported by Belasco (1970) and Holton (1967), high school physics enrollments have been declining for 50 years. Renner (1963), Van Koevering (1970), and Hurd (1972) report and/or express concern about declines in enrollments in college level science and engineering courses. These enrollment declines are thought to be at least in part a practical manifestation of the negative attitudes described in (1) above.

(3) Since 1956 vast sums of government and foundation money have been expended in the creation of new science curricula, which almost universally incorporate some goal statement relative to the fostering of positive attitudes towards science. The new high school physics courses were intended to halt the decline in physics enrollments.

(4) The decline in high school physics enrollments has not been miraculously reversed. Furthermore, empirical information indicating which courses and instructional techniques have the most promise for attitude development is not available. Such information is needed for decisions pertaining to choosing or developing curricula.

Design and Methodology

This was an exploratory study to identify predictors of high school students' attitudes toward Involvement (AIS) with Science and Perceptions of the Scientist (PS). Potential predictors included: (1) variables related to curriculum and instruction (including student perceived teacher characteristics), and therefore assumed to be under control of educators and schools; and (2) variables related to personal characteristics of the student or to his outside-of-school

experiences or environment which are assumed not to be under the control of schools. In order that this be a study of the "real world" as opposed to an artificially controlled situation:

-an instrument was designed to measure over 40 hypothesized predictor variables.

-data was collected at random from students in high schools which were selected to maximize heterogeneity of cultural, socio-economic and educational variables to be found in various parts of the country.

-results were analyzed by stepwise-deletion multiple regression. In this way variables of the second type above were treated as co-variates.

Instrumentation. A machine scorable instrument including Likert scales measuring AIS, PS, and two dimensions of academic self-concept, plus measures of over 40 other variables was developed. (See Table 1 for a list of the variables.) Items for the AIS and PS scales were selected, on the basis of face validity, from Cummings' (1969) instrument. The two academic self-concept scales, Self-concept of Present Academic Ability and Achievement (SCPAAA) and Self-concept of Future Academic Potential (SCFAP) were produced by converting Biggs and Tinsley's (1968) adaptation of Brookover's (1962, 1968) instrument from a Guttman scale to a Likert scale. The four Likert subscales had corrected odd-even reliabilities ranging from .75 to .89. Additional information was collected on a School Information Form.

Sampling. Science educators in various parts of the country selected schools in their areas to maximize heterogeneity of cultural, socio-economic and educational variables. They arranged for data to be collected from a random sample of 12 students from each of grades 10, 11, and 12 in each high school. Inclusion in the sample was not dependent upon which science courses students had taken or had avoided taking; rather measures of that information were taken and used as potential predictor variables. This sampling resulted in usable data from 373 students attending a broad spectrum of types of high schools in

Table 1. Modes of Measurement of all Variables in Revised Version of the Instrument used in the Study with a Selected National Sample.

Variable	Mode	Location
School ID	# Assigned	Answer Sheet
State ID	# Assigned	Answer Sheet
Physics Teacher (had, would have had, expect to have, or would have)	# Assigned to Name	Answer Sheet
Enrollment	# Provided	School Information Form
Urban-Rural	Ordinal Value 1 to 5 Assigned on Basis of Population and other Characteristics	School Information Form
# Years 13 "Alphabet" Science Courses (elementary and secondary) have been available in the system and in the building	Checklist	School Information Form
# Years and Date Last Offered for 10 "Alphabet" Science Courses which may have been "dumped"	Checklist	School Information Form
Physics Texts Available	Listed	School Information Form
IQ	Provided by Counseling Office	Answer Sheet

Table 1 (continued)

Variable	Mode	Location
GPA	Provided by Counseling Office	Answer Sheet
Grade	Multiple Choice	Answer Sheet
Age	Multiple Choice	Answer Sheet
Sex	Multiple Choice	Answer Sheet
Father vs. Guardian	Multiple Choice	Answer Sheet
12 Descriptors of Father's Occupation	Checklist	Answer Sheet
Mother vs. Guardian	Multiple Choice	Answer Sheet
10 Descriptors of Mother's Occupation	Checklist	Answer Sheet
Highest Educational Level of Father	Multiple Choice	Answer Sheet
Highest Educational Level of Mother	Multiple Choice	Answer Sheet
Socio-economic Level	Computed from Educational Levels and Occupational Descriptors	

Table 1 (continued)

Variable	Mode	Location
Cognitive Level of Parents' Work	Computed from Educational Level and Occupational Descriptors	
Enrollment Status in 7 Science Subjects	5 Point Ordinal Scale (reversed: 1 = having completed course)	Answer Sheet
11 Descriptors of the Physics Teacher	5 Point Likert Scales (poor description to good description)	Answer Sheet
Self-concept of Future Academic Potential (SCFAP)	6 Point Likert Scales	Answer Sheet
Self-concept of Present Academic Achievement and Ability (SCPAAA)	6 Point Likert Scales	Answer Sheet
Attitude toward Involvement with Science (AIS)	6 Point Likert Scales	Answer Sheet
Perception of the Scientist (PS)	6 Point Likert Scales	Answer Sheet

California, Wisconsin, Nebraska, Kansas and Pennsylvania. Some of the promised data, and even some collected data (from Illinois) was never received by the researcher. This resulted in a sample that was somewhat smaller than anticipated.

Analysis of Results

Regression models were developed by a stepwise-deletion multiple regression procedure. The alpha level for retention of a variable in a model was set at 0.05. Variables for inclusion were selected in the initial models for the first set of computer run on the basis of correlations with the criterion measure.

The First Set of Computer Runs. Results of the first run are shown on Tables 2 and 3. Examination of the final models revealed: six variables predicted 30.8% of the variance of AIS scores, and two variables predicted less than 5% of the variance of PS scores.

Sex and SCPAAA were in the final model for AIS. Liked as a Teacher (describing the physics teacher as) was the single most important predictor of AIS scores. Examination of the order of deletion revealed GPA and IQ to be among the poorest predictors. Educational Level of Father was a better predictor than Educational Level of Mother.

The final model for PS as presented in Table 3 consisted of smart (describing the physics teacher as) and scores on SCPAAA. Knowledge of what students thought of themselves and the physics teacher predicted almost 5% of the variability of the PS scores. The last predictor deleted was enrollment status in physics. SCFAP score was the third variable deleted from the model, indicating it was a rather poor predictor.

The Second Set of Computer Runs. The initial models for the second set of computer runs contained all of the variables in the final models from the first set of runs plus some additional variables of interest. Also added were four "manufactured" ordinal variables related to the origin of the data. These were

Table 2 - First Run on Stepdel. Criterion: Attitude toward Involvement with Science (AIS) N=373

Initial Model: Predictor Variable	Order of Deletion	Final Model: Alpha* for Retention in Model
GPA	4	
IQ	5	
Sex (maleness)		0.0008
Educational Level of Father	16	
Educational Level of Mother	8	
Enrollment Status in:		
Biology	1	
Physics	2	
Physical Science	13	
Chemistry	18	
Advanced Biology		.0418
Advanced Chemistry		.0001
Advanced Physics	11	
Physics Teacher Described as:		
Liked as a Person	6	
Liked as a Teacher		.0000
Smart	3	
Having Sense of Humor	15	

Initial Model: Predictor Variable	Order of Deletion	Final Model: Alpha* for Retention in Model
Physics Teacher Described as:		
Knowing Subject	14	
Interesting, Not Boring	17	
Respects Students' Interests	19	
Energetic, Dynamic, Active	9	
Seeks Students' Ideas	12	
SCFAP		.0008
SCPAAA		.0002
Socio-economic Level	7	
Cognitive Level of Parents' Work	10	

	Initial Model	Final Model
Coefficient of Determination (portion of variance of criterion accounted for)	.332 (corresponds to a correlation of .576)	.308 (corresponds to correlation of .554)
Significance of Regression	0.0000	0.0000

*Alpha is the level of significance of a t-test of the null hypothesis: This variable predicts none of the variance of the criterion.

Table 3 - First Run on Stepdel. Criterion: Perception of the Scientist (PS). N=373

Initial Model		Final Model	Initial Model		Final Model
Predictor Variable	Order of Deletion	Alpha for Retention in Model	Predictor Variable	Order of Deletion	Alpha for Retention in Model
GPA	19		Physics Teacher Described as:		
IQ	12		Smart		.0078
Sex (maleness)	11		Having Sense of Humor	9	
Educational Level of Father	6		Knowing Subject	4	
Educational Level of Mother	15		Interesting, Not Boring	10	
Enrollment Status in:			Respects Students'	2	
Biology	21		Energetic, Dynamic, Active	5	
Physics	23		Seeks Students' Ideas	7	
Physical Science	22		SCFAP	3	
Chemistry	13		SCPAAA		.0078
Advanced Biology	14		Socio-economic Level	8	
Advanced Chemistry	18		Cognitive Level of Parents' Work	16	
Advanced Physics	17				
Physics Teacher Described as:					
Liked as a Person	1				
Liked as a Teacher	20				

	Initial Model	Final Model
Coefficient of Determination (portion of variance of the criterion accounted for)	.111 (corresponds to a correlation of about .332)	.049 (corresponds to a correlation of about .221)
Significance of Regression	0.0182	0.0001

developed by ranking the correlations of binary variables, which identify state and school of origin, with the AIS and PS scores. Results of the second runs are shown in Tables 4 and 5.

The final model for AIS contains all the variables from the first run final model except advanced biology which was the last variable deleted from the model. Probably because of the deletion of advanced biology, advanced chemistry improved as a predictor. It was the best in the model! This is confirmation of the validity of the AIS scale. Additions to the final model were HPP and three of the four "manufactured" ordinal variables relating to origin-of-data. The poorest predictors of AIS scores were Urban-rural and Traditional Physics.

In the PS model (Table 5) Smart, a variable in the second run PS final model, was the last variable deleted. It was replaced by Biology, Physics, HPP, and two of the origin of data variables. Biology and Physics were in the initial PS model in the first run but were deleted. For some reason they looked better than Smart in the presence of HPP and the two origin-of-data variables. Liked as a Teacher was the poorest predictor.

The final model predicted 32.2% of the variance of AIS scores--a slight improvement over the first run. And 12.8% of the variance of PS scores was predicted--a marked improvement over the first run.

The 3rd Set of Computer Runs. The initial models for the third run (Table 6 and 7) on STEPDEL were comprised of the variables in the final models of the second run plus a few other variables of interest.

As reported in Table 6, PSSC 1st. Ed. replaced HPP, and the two origin-of-data ordinals based on correlations with PS scores in the AIS model. A check of the raw data revealed considerable entanglement of these variables. The displacement by PSSC 1st Ed. of three predictors from the previous model decreased the coefficient of determination by only .002.

Table 4 - Second Run on Stepdel. Criterion: Attitude toward Involvement with Science (AIS). N=373

Initial Model		Final Model	Initial Model		Final Model
Predictor Variable	Order of Deletion	Alpha for Retention in Model	Predictor Variable	Order of Deletion	Alpha for Retention in Model
Sex		0.0005	Availability of: (binaries)		
Enrollment Status in:			BSCS-Green	4	
Biology	8		CHEMS	11	
Physics	5		PSSC Second Edition	3	
Physical Science	9		Harvard Project Physics		.0007
Advanced Biology	12		Traditional Physics Text (mixed)	2	
Adv. Chemistry		.0000	State of Origin (Ordinal, ranked correlations with AIS scores)	7	
Physics Teacher Described as:			State of Origin (Ordinal, ranked correlations with PS scores)		.0081
Liked as a Teacher		.0002	School of Origin (Ordinal, ranked correlations with AIS scores)		.0008
Smart	6		School of Origin (Ordinal, ranked correlations with PS scores)		.0079
Respects Students' Interest	10				
SCFAP		.0010			
SCPAAA		.0001			
Urban-rural	1				

	Initial Model	Final Model
Coefficient of Determination of the Variance of the Criterion accounted for)	.345 (corresponds to a correlation of about .587)	.322 (corresponds to correlation of about .570)
Significance of Regression	.0000	.0000

Table 5 - Second Run on Stepdel. Criterion: Perception of the Scientist (PS). N=373

Initial Model: Predictor Variable	Order of Deletion	Final Model: Alpha for Retention in Model	Initial Model: Predictor Variable	Order of Deletion	Final Model: Alpha for Retention in Model
Sex	12		Availability of:		
Enrollment Status in:			PSSC Second Edition	9	
Biology		.0426	Harvard Project Physics		.0028
Physics		.0000	Traditional Physics Text (mixed)	7	
Physical Science	14		State of Origin (Ordinal, ranked correlations with AIS scores)	11	
Advanced Biology	13		State of Origin (Ordinal, ranked correlations with PS scores)		.0000
Advanced Chemistry	6		School of Origin (Ordinal, ranked correlations with AIS scores)		.0181
Physics Teacher Described as:			School of Origin (Ordinal, ranked correlations with PS scores)	4	
Liked as a Teacher	1				
Smart	15				
Respects Students' Interest	5				
SCFAP	3				
SCPAAA		.0202			
Urban-rural	8				
Availability of:					
BSCS Green	2				
CHEMS	10				

	Initial Model	Final Model
Coefficient of Determination (portion of the variance of the Criterion Accounted for)	.156 (corresponds to a correlation of about .394)	.128 (corresponds to a correlation of about .358)
Significance of Regression	0.0000	0.0000

Table 6 - Third Run on Stepdel. Criterion: Attitude toward Involvement. N=373

Initial Model		Final Model	Initial Model		Final Model
Predictor Variable	Order of Deletion	Alpha for Retention in Model	Predictor Variable	Order of Deletion	Alpha f Retenti in Mode
Sex		0.0010	PSSC First Edition		.001
Enrollment Status in:			PSSC Third Edition	14	
Biology	8		Harvard Project Physics	5	
Physics	10		State of Origin (Ordinal, ranked correlations with AIS scores)	7	
Advanced Biology	11				
Advanced Chemistry		.0000	State of Origin (Ordinal, ranked correlations with PS scores)	1	
Physics Teacher Described as:					
Liked as a Teacher		.0005	School of Origin (Ordinal, ranked correlations with AIS scores)		.024
Smart	2				
Respects Students' Interests	12				
SCFAP		.0002	School of Origin (Ordinal, ranked correlations with PS scores)	6	
SCPAAA		.0004			
Availability of the following:					
BSCS-Yellow	4				
BSCS-Blue	9				
CHEMS	3				

	Initial Model	Final Model
Coefficient of Determination (portion of the Variance of the Criterion Accounted for)	.350	.31
Significance of Regression	0.0000	0.0000

Table 7 - Third Run on Stepdel. Criterion: Perception of the Scientist. N=373

Initial Model		Final Model	Initial Model		Final Model
Predictor Variable	Order of Deletion	Alpha for Retention in Model	Predictor Variable	Order of Deletion	Alpha for Retention in Model
Sex	10		Availability of:		
Enrollment Status in:			CHEMS		.010
Biology	12		CBA	8	
Physics		.0000	PSSC First Edition		.013
Advanced Biology	11		PSSC Third Edition	1	
Advanced Chemistry	6		Harvard Project Physics		.000
Physics Teacher Described as:			State of Origin (Ordinal, ranked correlations with AIS scores)	5	
Liked as a Teacher	3		State of Origin (Ordinal, ranked correlations with PS scores)		.0000
Smart		.0209	School or Origin (Ordinal, ranked correlations with AIS scores)	7	
Respects Students' Interest	4		School of Origin (Ordinal, ranked correlations with PS scores)	8	
SCFAP	2				
SCPAAA		.0140			
Availability of the following:					
BSCS-Yellow		.0178			
BSCS-Blue	9				

	Initial Model	Final Model
Coefficient of Determination (portion of the Variance of the Criterion Accounted for)	.156	.138
Significance of Regression	0.0000	0.0000

In the PS model as reported in Table 7, Biology and the State of origin variable correlated with AIS scores were displaced by PSSC 1st. Ed., BSCS-Yellow, CHEMS, and Smart. The model predicted 13.8% of the variance of PS scores.

Scattergrams showed all new variables to the models to be well behaved. There was a slightly greater range of PS scores where BSCS-yellow was absent. There was a greater spread of AIS scores, especially to the low side, where PSSC 1st. Ed. was available.

Summary. The criterion measures from selected national data had slightly less variance than those from the Kansas pilot data. Yet less variance of dependent variables was predicted by the larger models developed from national data. This is evidence of the heterogeneity of the selected national sample.

The regression runs with national data were conducted in cumulative manner. Therefore the third run summarizes the process. Approximately 31.8% of the variance of AIS scores could be predicted from knowledge of: students' sex, their enrollment intentions with regard to advanced chemistry, whether or not they like the physics teacher as a teacher, their SCFAP and SCPAAA scores, the availability of PSSC 1st Edition, and the identity of the schools from which the data was collected.

Approximately 13.8% of the variance of PS scores could be predicted from knowledge of: students' enrollment status with regard to physics, whether or not students perceived the physics teacher as smart, students' SCPAAA scores, the availability of BSCS-yellow, CHEMS, PSSC-1, and HPP, and the identity of the states from which the data was collected.

Knowledge of the availability of specific curricula was more useful in predicting PS scores than AIS scores. Students' self concepts and perceptions of the physics teacher were predictive of AIS scores but not PS scores. The fact that knowledge of the identity of the schools in which data was collected was predictive of PS scores, suggests attitude toward involvement with science

may be affected by what occurs in schools, but perception of the scientist may be more dependent on regional cultural influences.

Some Incidential Results. The researcher was puzzled that students' enrollment status in a science subject seemed to be positively related to the criterion measures, whereas the specific courses available to students seemed to be negatively related to the criterion measures. To explore this the researcher went beyond the immediate objectives of this investigation and computed means of the criterion measures for selected subgroups of students who had completed or were taking some physics course. The results were tabulated in Table 8. No tests of hypotheses about means were performed.

AIS means of students who had completed or were taking physics were higher than AIS means of the total sample. This was not true of PS means. Students grouped on the basis of availability of HPP, regardless of the availability of other courses, had the highest means on both scales--higher than the means of the total group of students who had completed or were taking physics. The group with PSSC 1st edition available to them had means slightly below those of the HPP group. Various combinations of offerings produced a wide range of means. However, only one or two schools offered each combination so any differences were confounded with differences between schools.

The means for the 200 students with HPP available to them (regardless of whether or not they took physics) were:

AIS mean = 66.1 PS mean = 58.0

These were nearly the same as the means for the total sample. Apparently the mere availability of HHP did not result in higher AIS or PS scores of the general population of high school students. Course reputation did not influence AIS or PS, but taking the course may have.

Table 8 . Means of AIS and PS Scores of Selected Groups of Students who Completed or Were Taking High School Physics.

# of Students (completed or taking physics)	Course Available (regardless of availability of others)	AIS Mean	PS Mean
52	HPP	72.1	60.0
65	PSSC 1st Ed.	69.9	59.2
50	PSSC 2nd Ed.	68.8	58.0
50	Any Traditional Physics Text	67.9	58.0
44	Any Physics Courses except HPP	67.0	58.3
	Combination of Courses Available		
7	HPP, PSSC-1, PSSC-2	77.8	65.7
11	HPP, PSSC-1, PSSC-2, PSSC-3	71.7	60.7
4	HPP, PSSC-2, Traditional	54.6	55.0
18	HPP, PSSC-1	73.4	60.8
11	HPP, PSSC-1 Traditional	70.0	61.5
18	PSSC-1, PSSC-2, Traditional	62.0	56.6
1	HPP	58.0	60.0
17	Traditional	73.0	61.3
10	PSSC-2	72.0	55.9
96	Any Course	70.0	58
Means from Total Sample of 373 Students		66.9	58.0

On a hunch, the researcher calculated the mean IQ's of students who had completed or were taking physics. The results were:

	Mean IQ (100 substituted for missing scores)	Mean IQ (missing scores deleted from computations)
Physics students where:		
HPP available	110.0	117.0
HPP not available	123.0	130.0
All students in the sample	110.7	

Where HPP was available, students with lower IQ's were taking physics!

These results suggest that additional analysis of this data should include tests of hypotheses about differences in AIS and PS scores of physics students having different curricula available to them. Similar analyses should be performed on data from students who have completed or are taking biology and chemistry. All of these analyses should also be performed with the data grouped by sex.

Conclusions

This study resulted in the identification of variables that are significant predictors of high school students' Attitudes toward Involvement with Science and Perceptions of the Scientist. It provides direction for additional investigations. Some of the predictors appear likely to be influences on attitudes, however, causality is not proven.

(1) The availability of BSCS-yellow, CHEMS, HPP, and PSSC-1st edition explains significant amounts of the variance of AIS and PS scores, but the direction of any possible influence is not clearly determined.

(a) There is no evidence that the availability of any of the "alphabet" courses promoted higher or more favorable AIS or PS among the general population of high school students.

(b) Students who were taking or had completed some science subjects and hence had experienced some of the "alphabet" courses had higher AIS and PS means than the general population of students.

(c) Physics students attending schools where Harvard Project Physics was available (regardless of what other physics course was available) had higher AIS and PS scores than did physics students attending schools where HPP was not available. The average IQ of physics students attending schools where HPP was available was lower than is typical of physics students--about the same as that of the general population of high school students.

(2) Perception of self, perception of the physics teacher, and sex designation were as important in predicting AIS and PS scores as the science curricula available.

(3) More of the variance of AIS and PS scores can probably be explained by some as yet unidentified variables. A variable identifying data sources in terms of schools was a significant predictor of AIS scores. A variable identifying data sources in terms of states was a significant predictor of PS scores. This suggests that AIS may have some additional unexplained dependence on formal education and PS may be dependent on regional, cultural differences.

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